Constructing an outdoor kiln

Science in Technology Education Team
*Wigan Education Authority**

Traditional Lakeland rain was falling and a breeze was blowing across Rydal as the Deyes High Team, clad in boots and waterproofs, set up the hill to execute their brief. In the shelter of a high wall and a barn the brief was studied:-

a Construct a kiln to fire 3 clay bricks of given dimensions.

b Construct a device to reproduce any number of clay bricks to the uniform size of 25mm x 25mm x 100mm.

It soon became clear that three would work on the kiln while two worked on the bricks and a bonfire to provide warmth, cheer and, of course, fire to anyone who required it. Rumour has it that the actual brief was used as a 'resource' to light the bonfire.

A site was located against a platform wall outside the barn to serve as a support for the rear of the kiln. (See picture 1).

Soon the hillside, and local environment, yielded such useful items as bricks, tiles, pipes, supermarket basket, an axe, wood, nails, some basic 'borrowed' tools and other useful materials. The team set about the tasks with a lively enthusiasm and occasional bursts of sunlight added to the scene. Picture 2 shows the early stages of the kiln, whilst picture 3 illustrates the lining of the kiln with local, and freely available mud.

Soon as picture 4 shows, the kiln's frame was in existence and ready to have the outer insulation of sods applied.

Above: (1) The site with bonfires ablaze. Below: (2) Early stages of kiln

** The task was part of a three day course at Rydal in the Lake District and conducted by British Schools Technology centred at Trent Polytechnic.*

The team: Mr John Ashton, Mr Ian Cookson, Dr Alan Cundall, Mr Edward Sims and Mr Geoff Halligan, who wrote the account; all members of the Deyes High School, Science Staff at Magull.

John Thompson, Wigan Advisory Service, was responsible for the brief.

Above: (3) Lining the kiln with mud.
Below: (4) The kiln ready for firing and exterior insulation.

Using 'on site' technology, fire was transferred to the fire-pit of the kiln (Picture 5).

Soon a lively fire was blazing.

Meanwhile in the barn the brick mould was developing. Some 'handy' plastic right-angled strips were fixed to a board to the size specifications. A cheesewire device enabled two bricks at a time to be produced (Picture 6).

Various samples of clay were used and some 'acquired' sea-grass was used as 'straw' in some bricks. Holes were fashioned in the bricks to further heat penetration but the upright dowels in the mould were soon removed to ease removal of bricks. It was found easier to pierce the moulded bricks with a tool. Bricks were labelled and some were dried around the bonfire. One was left in the heart of the bonfire and the others transferred to the kiln (Picture 7).

By lunchtime the kiln was heating up well, bricks were being produced and the five team members stood and contemplated the fruits of their labours. We stoked up, fitted a temporary 'plastic chimney' and left with certain crucial questions forming for discussion over lunch (Picture 8).

i. How could we improve the draught?
ii. How could the temperature be raised?
iii. What could we use as bellows?
iv. How could we monitor the temperature in the kiln?
v. How could we conserve more heat?
vi. How could we direct more air to the underneath of the fire-pit?

After lunch we returned to find an almost empty fire-pit so we set about our tasks. There was a frantic wood chopping to provide fuel and during the afternoon continuous sophistication of the kiln took place as we answered our questions.

i. An earthenware chimney considerably increased the draught.
ii. The temperature was raised by chopping the wood smaller and sealing more areas of the kiln.
iii. Two rubber hot water bottles served as bellows to direct air at the fire. A prototype using a polythene bag between two pieces of wood failed to deliver sufficient draught.
iv. We decided to 'find' some local lead and insert it in the kiln alongside the bricks. When it melted we knew we had reached 330°C. We added some aluminium and when that melted we knew we were up to 660°C. A hunt for some copper was unproductive.
v More sods were added to aid insulation all round the kiln and more gaps were plugged with rubble and sods. A piece of asbestos served as a kiln door and later a piece of aluminium was used to fill the fire-pit entrance.
vi. A piece of metal downspout, which was cracked along its length, was inserted into the fire pit to serve as a tuyère.

During the afternoon we noticed that bricks were behaving differently. The one left in the bonfire was hard but had crumbled and was easily reduced to dust. The bricks without straw cracked apart or exploded. Those with straw were turning a greyish colour in the kiln and retaining their shape. Our prize brick turned out to be one made from grogged clay with

Right: (5)Technology at work to move fire. Below right: (6) The double-brick mould (Modified later).

straw added and air-holes pierced before firing.

As evening approached we finally stoked up, sealed all gaps and put the bonfire around the kiln. A final check revealed a couple of bricks beginning to glow red and very bright almost white hot; charcoal was visible at the end of the tuyere. By all reasonable counts we had executed out brief but at 7.00a.m. next morning the first team member was inspecting the bricks. Others were up soon after. Experts who saw the bricks assessed them as fired to earthenware which indicated that the kiln had reached some 1100°C. So what had the five of us really achieved. Some quotes from staff are used to indicate observations and attitudes.

'We had the added advantage that the problem was one in which there was an end product which could be seen (handled, boasted about, what have you!). I think this was quite important.' 'The composition of Deyes team is fortunate in that there is no-one attempting to dominate, no-one striving for recognition from their peer members and we all get on well together.' 'I cannot remember exactly how the various tasks were taken up by different members, just that it appeared to occur fairly naturally. This means that each member or sub-group of members was aware of the total problem in sufficient detail to be able to see what the next necessary job was.'

'The one part which was a failure — the bellows! We should have got together as a complete team. I know I did'nt make an adequate contribution in this area. We decided that we had not got the right materials and could not get them and that we would try to get a sufficiently hot furnace without the bellows. We succeeded in this but the result would have been better if we had persevered and solved the problem.'

'It's education folks, but not as we know it — it's education folks but not as we know it'. 'It proves that we can work as a team in difficult conditions with the minimum of equipment.' I am sold on the idea, the actual experiment didn't really matter — although I think we picked one of the best! — partly because we knew so little about it. Therefore, we did not have a lot of preconceived ideas. It made me think.' 'The amount of effort that went into it proves the enthusiasm for the project. I would wish to set some of this type of exercise during the GCESE and A level courses and to explore the use in lower school science. As a result of the activity I am already thinking of a GCESE/A level exercise based on the problems of expanding a holiday camp on a sand dune system containing rare plants and animals.'

'What am I doing with the hot water bottle? I'm trying to get a b..... draught up the kiln, aren't I!!?'

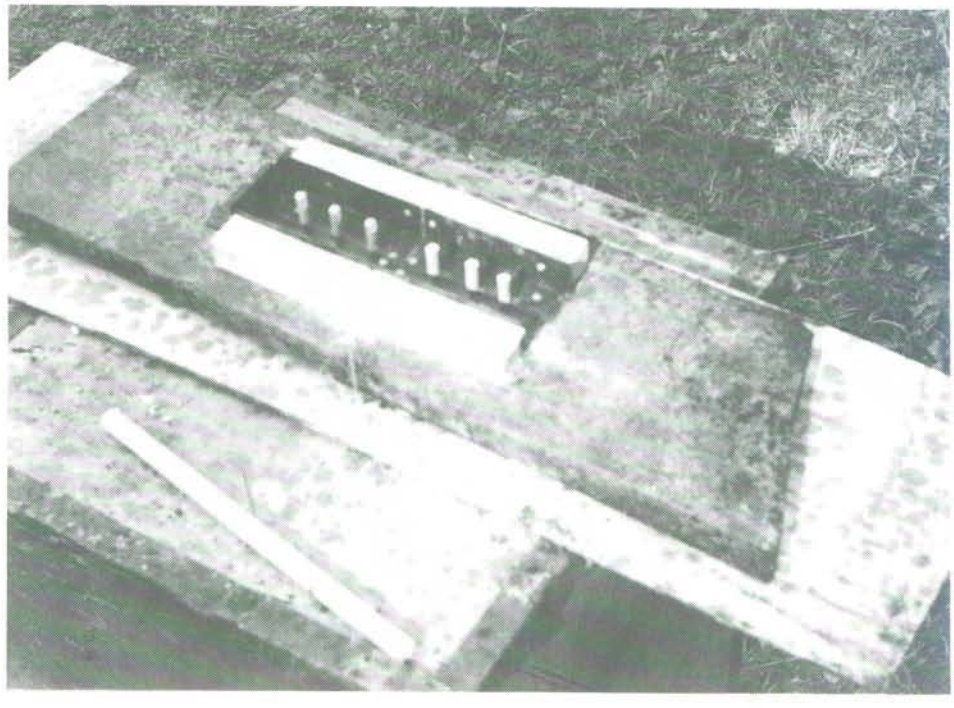
In attempting to decide what is technological, scientific and cross curricular the following suggestions have been received.

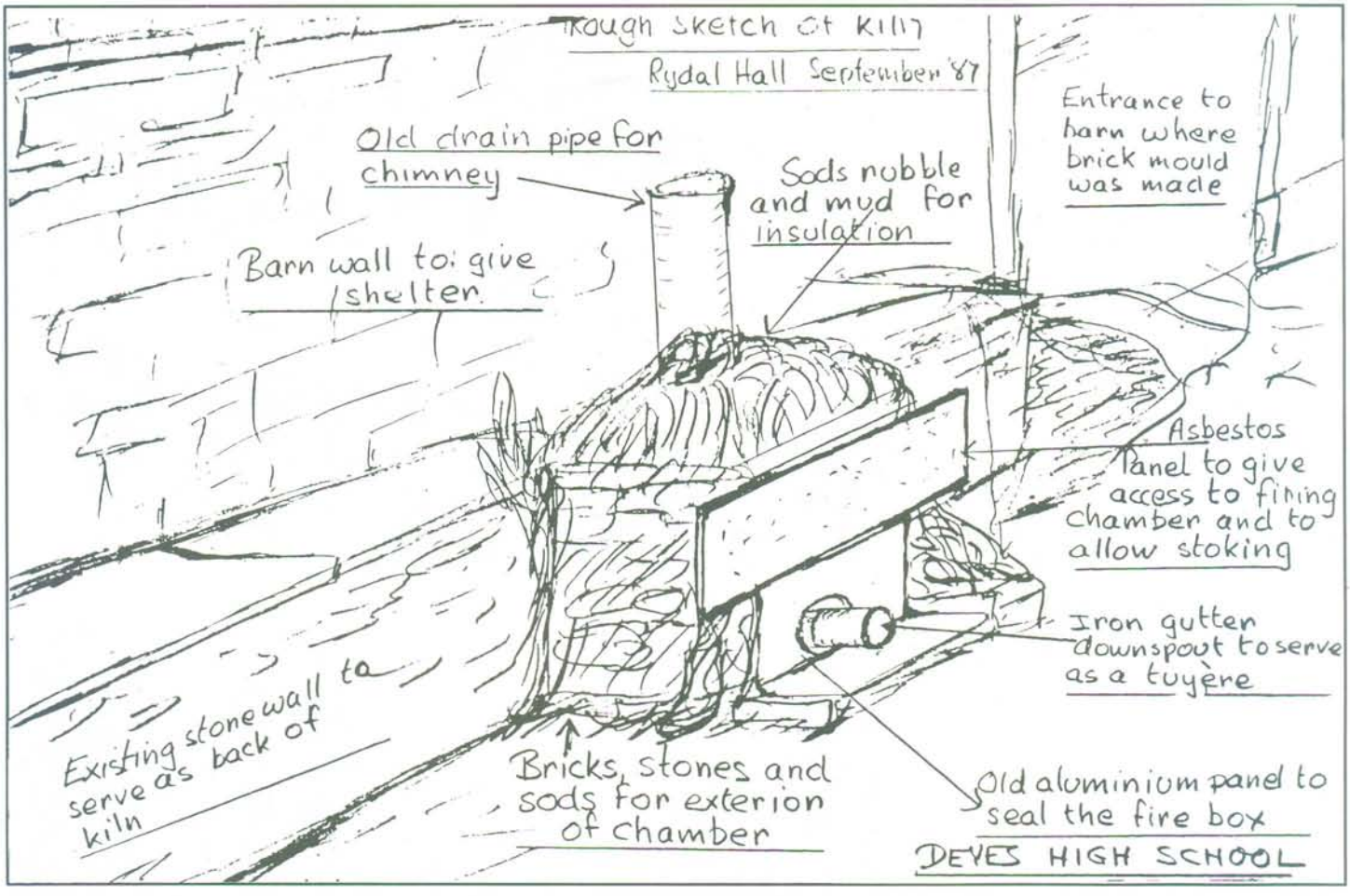
Technological:-

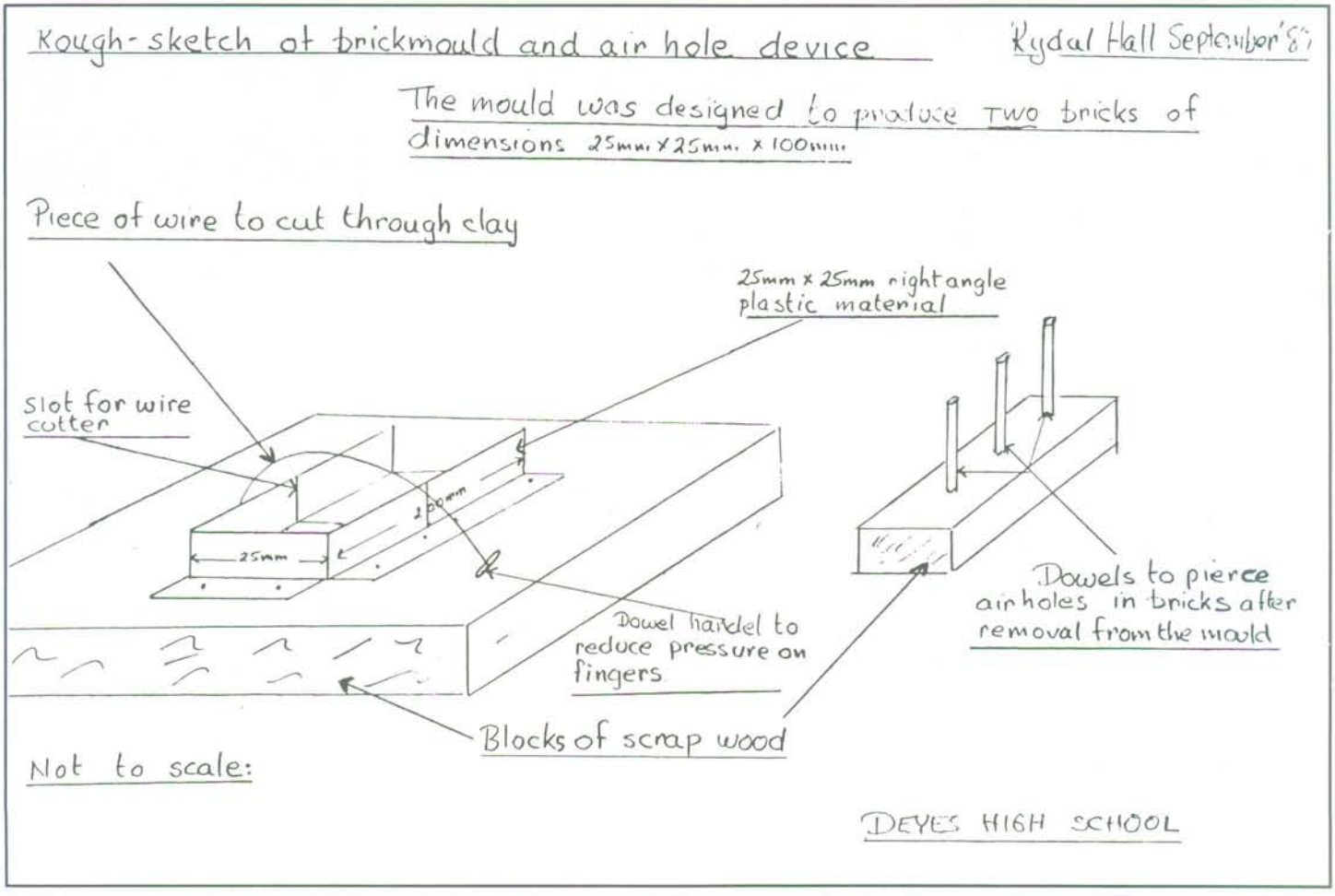
— Use of resources — including staff.
— Design and construction of brick mould.
— Use of materials.
— The cheese-cutter wire and finger grip.
— The removal of the bricks from the mould.
— The design and construction of the kiln.
— Selection of suitable available materials.
— Modifications to chimney, tuyère and trivet
— Tool to carry fire from bonfire to kiln.

Scientific:-

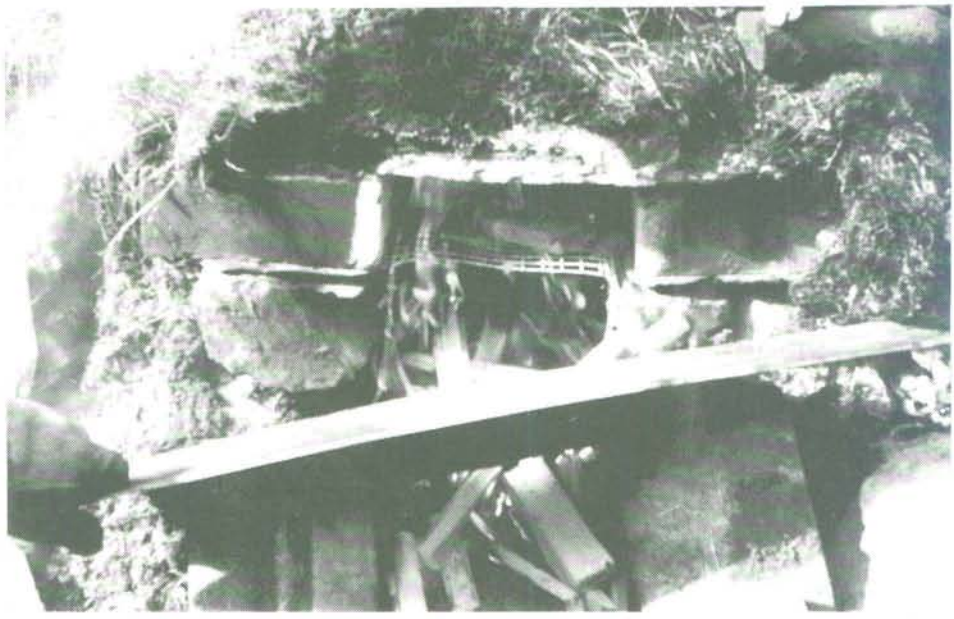
— The wire cutter — fine wire pressure.
— The melting point of the wire tray/trivet.




Rough sketch of kiln
Rydal Hall September '87
Old drain pipe for chimney
Sods rubble and mud for insulation
Entrance to barn where brick mould was made
Barn wall to give shelter
Asbestos panel to give access to firing chamber and to allow stoking
Iron gutter downspout to serve as a tuyère
Existing stone wall to serve as back of kiln
Bricks, stones and sods for exterion of chamber
Old aluminium panel to seal the fire box
DEYES HIGH SCHOOL


Rough-sketch of brickmould and air hole device
Rydal Hall September '87
The mould was designed to produce two bricks of dimensions 25mm. x 25mm. x 100mm.
Piece of wire to cut through clay
25mm x 25mm right angle plastic material
Slot for wire cutter
100mm
25mm
Dowel handel to reduce pressure on fingers
Dowels to pierce air holes in bricks after removal from the mould
Blocks of scrap wood
Not to scale:
DEYES HIGH SCHOOL

Right: (7) Bricks being fired in kiln.
Bottom right: (8) How can we improve this?



— Slate would explode in the heat so not used.
— Need of chimney to draw oxygen to fire.
— Need for tuyère to direct oxygen to seat of fire.
— Charcoal took temperature higher: better than flames.
— Melting points of lead and aluminium needed to be known.
— Insulation
— Convection
— Additives to clay.
— Chemical reactions in clay.

Cross-curricular: (limited on site but could include)

— Discussion and communication skills between group members.
— Geography — clay/building materials, fuel available in area?
— Social — Third World application/Who does what?
— CDT — Sketching/design.
— Mathematics — costings — measurement — efficiency.
— History — consideration of basic skills and their development.

A further member of the team completed an analysis of the activity using the SITE revised tools of analysis and this is included below:-

OUTDOOR ACTIVITY AT RYDAL HALL
Tools and Analysis applied:

a: Science Aspects

Scientific Purpose:
To provide an opportunity for pupils to apply and improve their class room gained knowledge in a real life situation.

The pupils were successful as a kiln was constructed which produced a very high temperature (abt. 1100°).

Scientific knowledge/skills:
1 The pupils were expected to apply their knowledge of insulation properties and the importance of convection in construction of a kiln.
2 Measurement of temperature without any thermometer.
3 The need to control change of variables during an experiment.

All of the above skills and knowledge were used.

New Science learning:
(If applied to Year 4 pupils and not teachers)

1 Use of different materials as insulator.
2 Use of convection (forced) to produce high temperatures.
3 Methods of finding temperature without thermometer. This was done by seeing if various metals melted when placed in the furnace. This obviously means one of the group, at least, needs to be aware of melting points.

b) Technology Aspects

Realistic context:
Yes, as ideas could be used in 'Third World' and linked to a Cross Curricular scheme.

The pupils were highly motivated and achieved satisfaction in final outcome.

Application of Technology skills:

1 Construction of kiln: Need for firm foundation.
2 Selection of materials from the environment.
3 Construction of mould for brick to give reproducible results.
4 Production of bellows.

The group used all the above skills but did not construct bellows, instead they chose to use a hot water bottle!

Opportunities for objective decisions and value judgements.
Group continually had to make decisions in construction of kiln and bricks as well as selection of suitable materials.

Opportunities for group/self managements.
The activity included many tasks which could easily be allocated to individuals or sub groups of the group.

Left: (9) The final version of the kiln. (Fire-pit seal still to be fitted)

The pupils split into two teams, one to build kiln, one to construct bricks. Within these teams individuals undertook various tasks without direction but usually after group discussions. The teams joined together as a group naturally when one of the activities had finished. The individual expertise and knowledge of the group were well used.

S.I.T.E.

KILN DESIGN

1 From the materials available design and make an outdoor kiln which will fire a small brick 100mm x 50mm x 25mm from each of the three types of clay provided and one from site.
2 Investigate and record as many of the scientific data as is practical in this technological production.
3 Evaluate the outcomes related to the kiln design and the finished product.

Notes

1 Brick construction
Cutting
Shaping
Measuring
Uniformity

2 Firing
Slow Heat
Intense Heat
Thermal Shock
Temperature x Time

3 Changes
State
Chemical
Shape
Colour

4 Heat Exchange
Maintain Temperature
Create the highest possible temperatures
Added oxygen — draught

What new technological learning was expected:

1 Construction of a kiln.
2 The need to dry clay out slowly in order to avoid splitting.
3 The need for straw or similar in bricks to avoid formation of steam and hence splitting of brick.
4 The need for very high (1000°C) temperatures.
5 Production of a mould to produce bricks of repeatable size.

Cross Curricular Opportunities provided:

This was limited in the context as presented but could easily be developed into a cross curricular project.

For example:
Shelter — problems of lack of shelter in 'Third World' countries — need for brick making — links with Geography, History, Mathematics, Economics, etc. etc.

General Education Aspects:

What other new learning was expected?

Personal qualities:

Need for co-operation, teamwork, innovation, observation.

The group spirit and motivation was high. Each member of the team took full part in all the activities. The spirit of innovation and use of local materials was very high. The group enjoyed having to seek for relevant materials.

CONCLUSION

The team worked well together, enjoyed the activity and executed the brief despite poor weather conditions initially and limited resources. Morale was high and enthusiasm was evident. A combination of acquired knowledge and the deductive process, drawing on the expertise of each team member, enabled a more than satisfactory completion of the brief. Further, the experience has encouraged staff to use the process in teaching situations back at school and has consolidated already strong working relationships between staff.

The sketches indicate the completed versions of the brick mould and kiln but the positive effects on the staff are not as easily illustrated. We think we know what they are and have tried to explain them. We trust that our teaching is enriched and that pupils find it more relevant and stimulating — time will tell! We found the Rydal Experience enjoyable, positive, stimulating and challenging. We believe that we are the better for it..